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Title: Gallup High STEM Project- LANL Explosive Educations in STEM

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Bigger, Rory Paterson

Intended for: Presentation to Gallup High School STEM program students in support of the Partnerships & Pipeline Office program

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Los Alamos
NATIONAL LABORATORY

Gallup High STEM Project- LANL Explosive Educations in STEM

Matthew Biss & Rory Bigger

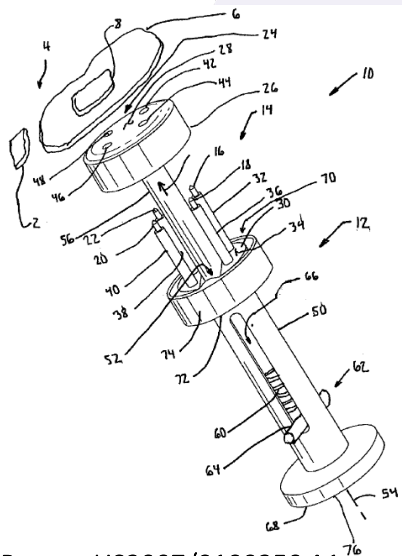
May 17th, 2021

Matt’s STEM career path…

The University of Toledo: Bachelor of Science

- Enrolled in Biomedical Engineering

GLOBAL ADVANTAGE® Shoulder Arthroplasty System



US Patent: US2007/0100350 A1

Distal Tibia T-Plate

  - After 4 years → Mechanical Engineering

It’s okay to change your educational path…

The Pennsylvania State University: Doctor of Philosophy

The Pennsylvania State University

The Graduate School

College of Engineering

CHARACTERIZATION OF BLASTS FROM LABORATORY-SCALE

COMPOSITE EXPLOSIVE CHARGES

A Dissertation in

Mechanical Engineering

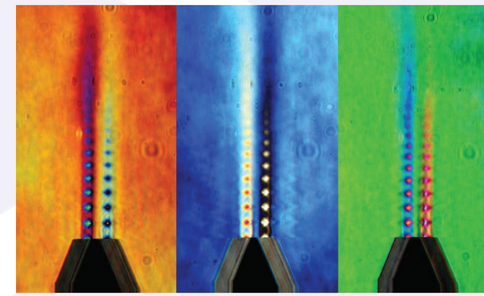
by

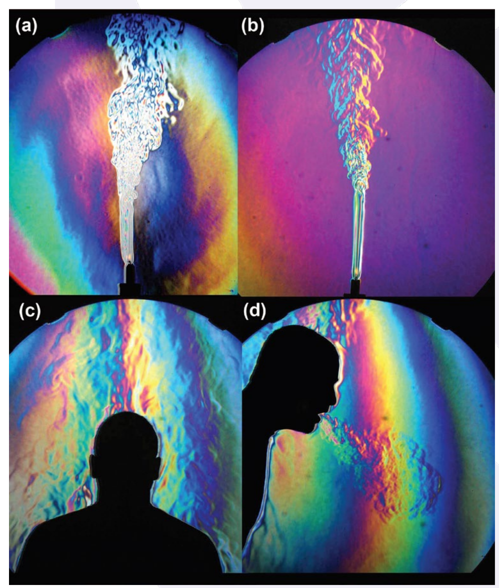
Matthew Michael Biss

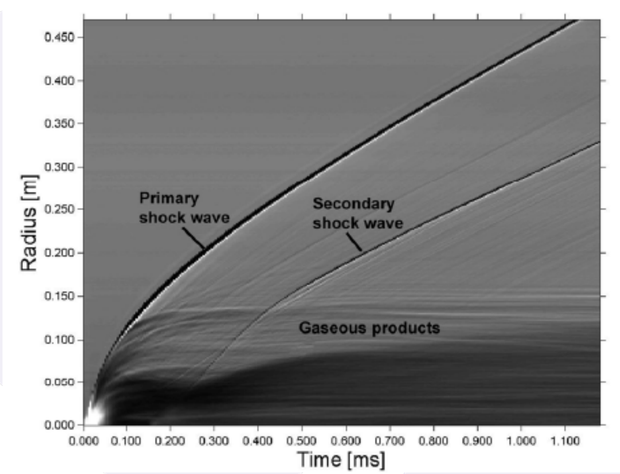
Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

December 2009







US Army Research Laboratory: Postdoctoral Research Associate/R&D Engineer (Civilian)

Optically measured explosive impulse

Matthew M. Biss · Kevin L. McNesby

Received: 15 March 2013 / Revised: 6 May 2014 / Accepted: 9 May 2014

Abstract An experimental technique is investigated to optically measure the explosive impulse produced by laboratory-scale spherical charges detonated in air. Explosive impulse has historically been calculated from temporal pressure measurements obtained via piezoelectric transducers. The presented technique instead combines schlieren flow visualization and high-speed digital imaging to optically measure explosive impulse. Prior to an explosive event, schlieren system calibration is performed using known light-ray refractions and resulting digital image intensities. Explosive charges are detonated in the test section of a schlieren system and imaged by a high-speed digital camera in pseudo-streak mode. Spatiotemporal schlieren intensity maps are converted using an Abel deconvolution, Rankine-Hugoniot jump equations, ideal gas law, triangular temperature decay profile, and Schardin's standard photometric technique to yield spatiotemporal pressure maps. Temporal integration of individual pixel pressure profiles over the positive pressure duration of the shock wave yields the explosive impulse generated for a given radial standoff. Calculated explosive impulses are shown to exhibit good agreement between optically derived values and pencil gage pressure transducers.

List of symbols

D_{ij}	Linear operator
EBW	Exploding bridgewire
f	Focal length
Hg–Xe	Mercury–Xenon
I^+	Positive phase of explosive impulse
k	Gladstone-dale coefficient
M	Mach number
N	Number of intervals
P	Pressure
PETN	Pentaerythritol tetranitrate
P_0	Atmospheric pressure
P_s	Peak shock wave pressure
R	Lens radius
r	Radial lens coordinate
r_i	Distance from center of object of interest
r_0	Radial lens coordinate exhibiting luminance
R_{air}	Air gas constant
RDX	Cyclotrimethylene trinitramine
T	Temperature
T_{max}	Peak shock wave temperature
T_{min}	Temperature at $t_a + T^+$
t_a	Shock wave time of arrival
t_m	Time vector
T^+	Positive pressure phase duration
w	Graded filter width
Δr	Data spacing interval
δ	Normalized refractive index difference
γ	Specific heat ratio
ε	Refraction angle
ε_{min}	Minimum refraction angle
ε_0	Lens refraction angle constant
η	Refractive index
η_0	Refractive index at ambient conditions

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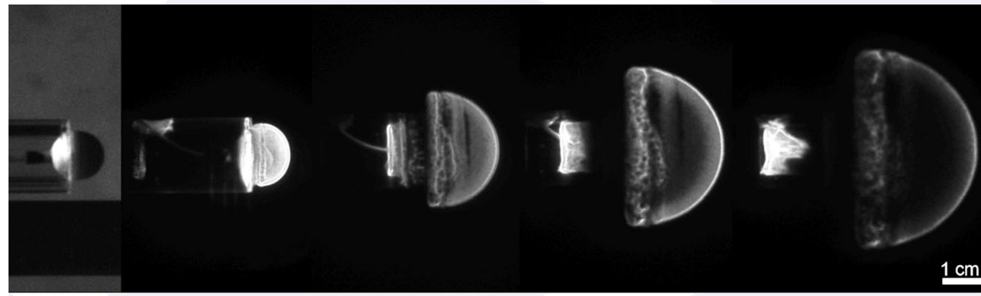
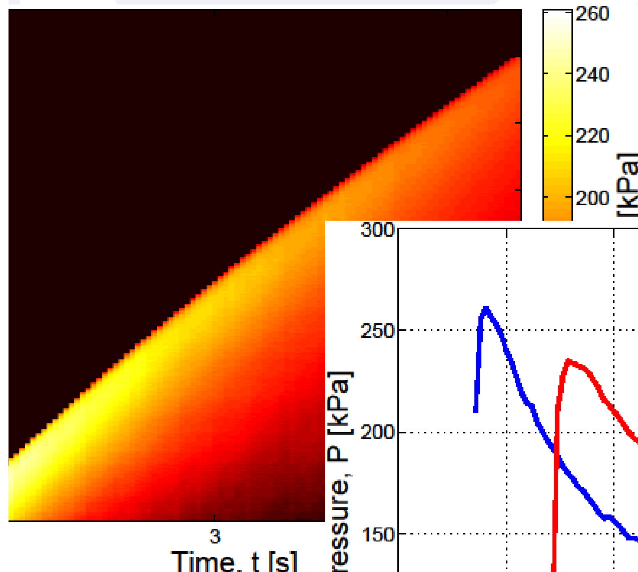
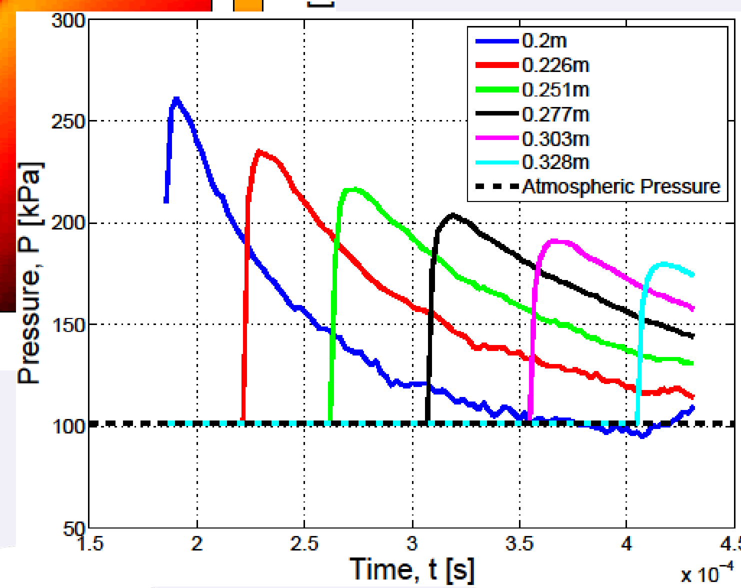
Published online: 24 May 2014

Springer







Los Alamos National Laboratory: R&D Engineer

Overdriven-Detonation States Produced By Spherically Diverging Waves

Matthew Biss[a)], Mark Lieber, and Michael Martinez

Los Alamos National Laboratory, Los Alamos, NM 87545, USA

[a)]*Corresponding author: mbiss@lanl.gov*

Abstract. A series of experiments are currently underway at the Detonation Science and Technology group, within Los Alamos National Laboratory, to study the overdriven-detonation states achievable in energetic materials as a result of detonation-wave interactions. A multi-component, energetic-material array was designed to study the amplification of velocity and pressure states produced by spherically diverging detonation waves in pentaerythritol tetranitrate (PETN) output charges. The unique geometry provides a low-jitter, highly controlled series of interactions between three independent-detonation inputs. Streak-camera imaging was performed on the output face of PETN pellets ranging in thickness from 2.5 – 10 mm to characterize the resulting breakout profile. Additionally, photonic Doppler velocimetry (PDV) measurements were collected at the output-pellet surface to determine simultaneity within the system. Detonation-wave velocities upwards of 16 mm/μs were measured, as compared to a steady-state detonation velocity of 7.9 mm/μs for the PETN pressing density investigated. Additional experiments are being conducted to measure the pressure amplification generated at key areas of interaction.

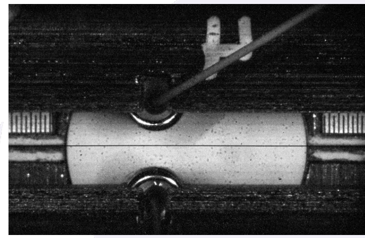
BACKGROUND

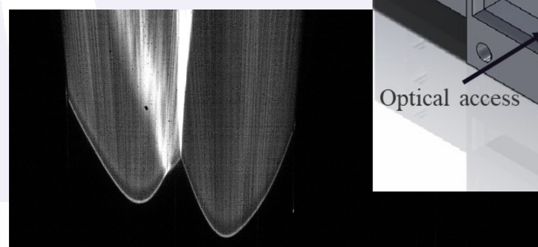
Overdriven-detonation states are known to exist in high explosives, however, the underlying physics dominating the mechanism with which these states are achieved are not well understood at the detonator scale (i.e., sub-gram charge quantities). This is in part due to the difficult-to-probe spatiotemporal regime (microns and nanoseconds) that results from the presence of three-dimensionally dominant, spherically diverging, multi-wave interactions. In an effort to continue the modernization of future detonator technologies, it is therefore necessary to improve the understanding of the physics associated with these types of interactions. As such, the research presented herein aims to expand upon the fundamental groundwork laid by Hull [1, 2] and Francois [3] to a three-point-initiation configuration near the detonator scale and determine its viability by characterizing the evolution of overdriven states.

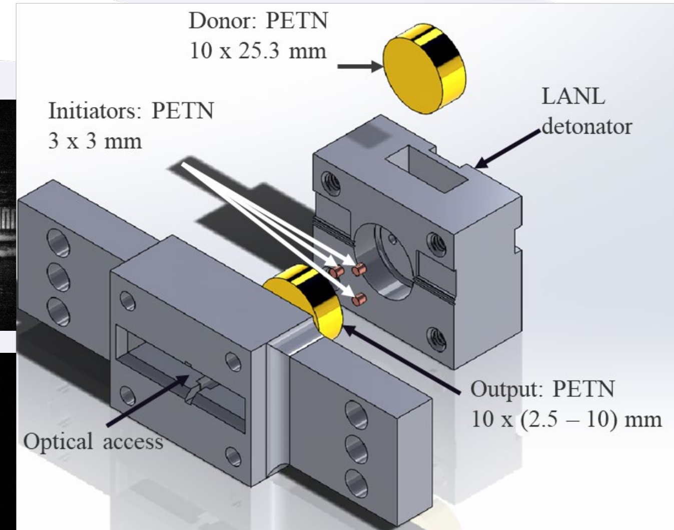
EXPERIMENTAL METHODS

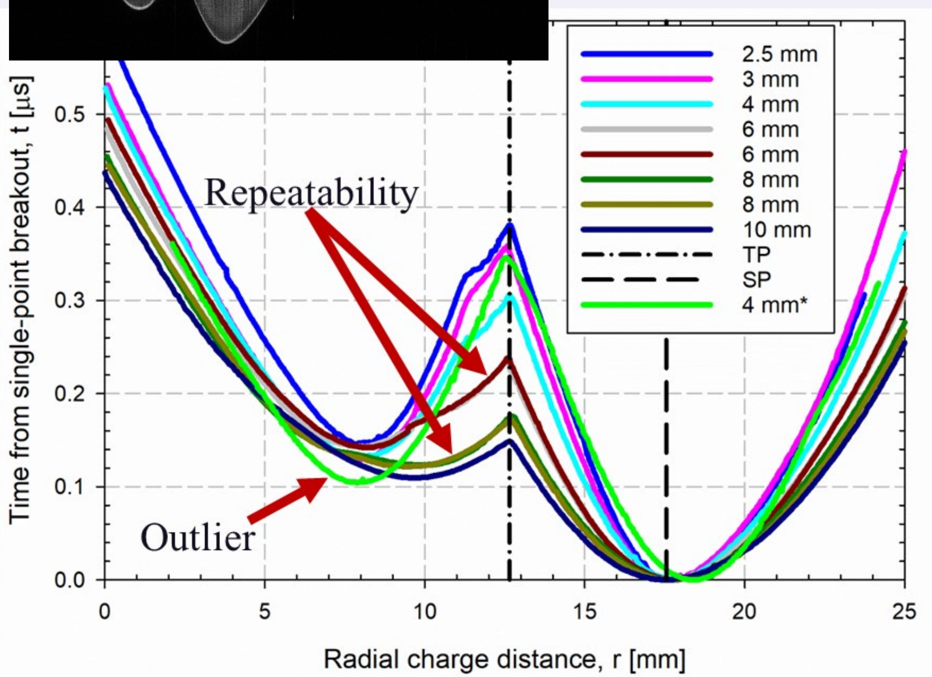
Energetic-Material Array

A multi-component, energetic-material array is implemented to study the formation, growth, and decay of overdriven-detonation states produced by spherically diverging detonation waves in pentaerythritol tetranitrate (PETN) output pellets, Fig. 1. The array is built upon three-dimensional (3D) printed fixtures to contain the energetic-material array and diagnostics of interest. The energetic-material array consists of a PETN donor pellet (ρ=1.65 g/cc, 25.3-mm diameter, and 10-mm heighth) that is centrally initiated by a single high-precision detonator developed at Los Alamos National Laboratory (LANL). The PETN donor pellet subsequently initiates three PETN initiator pellets (ρ=1.65 g/cc, 3-mm diameter, and 3-mm heighth) placed radially 6.4 mm from the center of the donor charge and at 120-degree increments. The donor-initiator pellet configuration is chosen to achieve a high degree of simultaneity across the three initiator pellets that is not achievable thru implementation of a multipoint







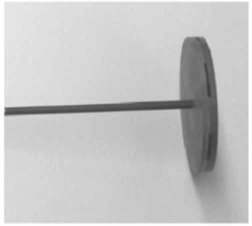


Rory’s STEM career path…

Syracuse University: Bachelor of Science

- Enrolled in Computer Science
- Switched to Aerospace Engineering during Freshman year
  - Interested in fluid mechanics
  - Summer research funded by NASA grant

AIAA JOURNAL
Vol. 47, No. 5, May 2009

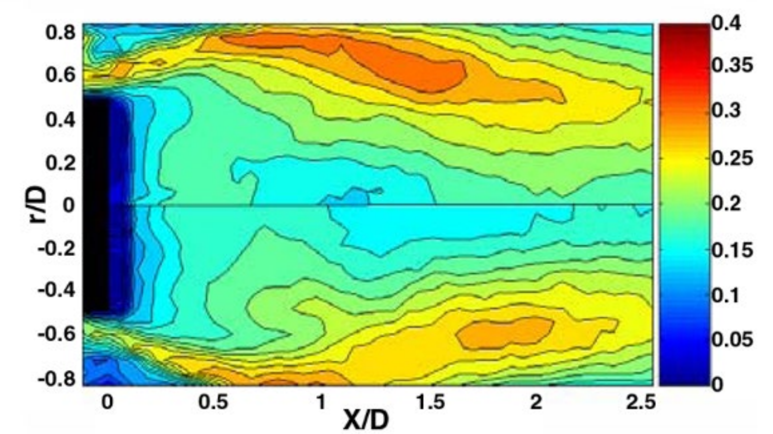


Open-Loop Control of Disk Wakes

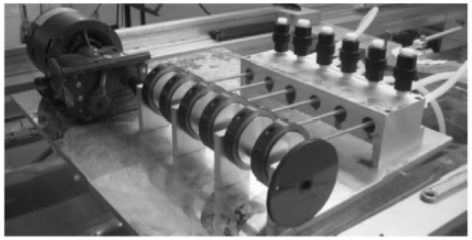
Rory P. Bigger,* Hiroshi Higuchi,† and Joseph W. Hall‡
Syracuse University, Syracuse, New York 13244

DOI: 10.2514/1.39108

Open-loop control in the near wake of a disk in subsonic air and water flows was investigated using particle image velocimetry at a Reynolds number based on the disk diameters of 67,000 and 20,000, respectively. The air model had tabs along the edge that were driven radially by electromagnetic actuators, and the water model had slots connected to a piston and cylinder external to the flow. In both systems, the frequency of actuation could be varied, and in air, the spatial extent of the forcing could be controlled. Symmetrical actuation produced a reduction in the recirculation-region length of 10% for both air and water. Additionally, a helical excitation at the fundamental natural vortex-shedding frequency in air caused a reduction of 15% and caused the wake to oscillate strongly in phase with the excitation. The most effective symmetrical actuation frequencies correspond to twice the natural frequency of the asymmetric mode in the unforced wake. The effects of actuation on the instantaneous and mean velocity fields are presented and discussed in detail.



- Job market in aerospace tight in 2006 when graduated
  - Went to a talk by Dr. Gary Settles from Penn State
  - Thought they were doing cool work and went to join them



It's okay to change your educational path…

The Pennsylvania State University: Master of Science

The Pennsylvania State University

The Graduate School

College of Engineering

CHEMICAL VAPOR PLUME DETECTION USING

THE SCHLIEREN OPTICAL METHOD

A Thesis in

Mechanical Engineering

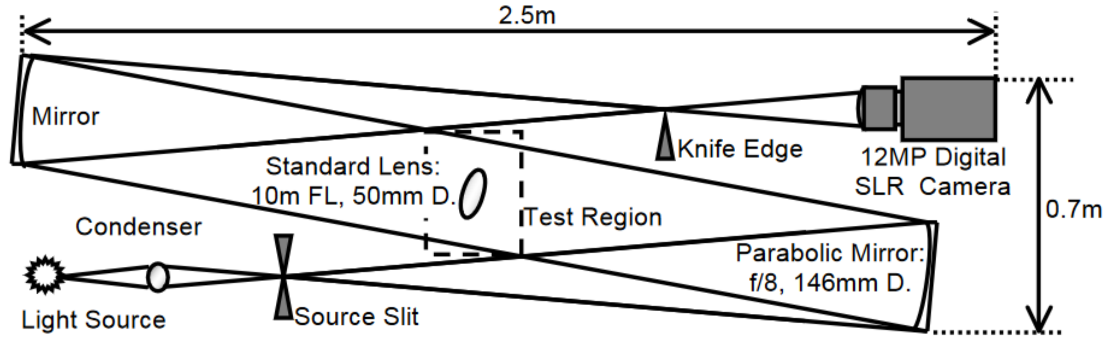
by

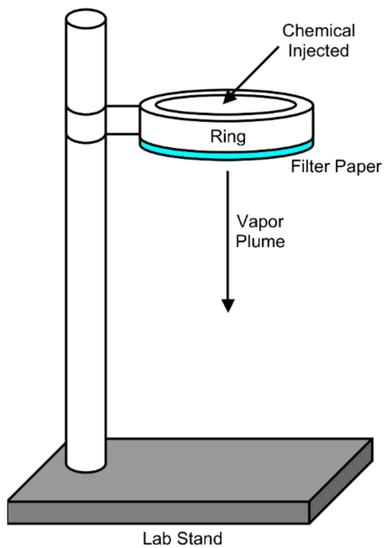
Rory P. Bigger

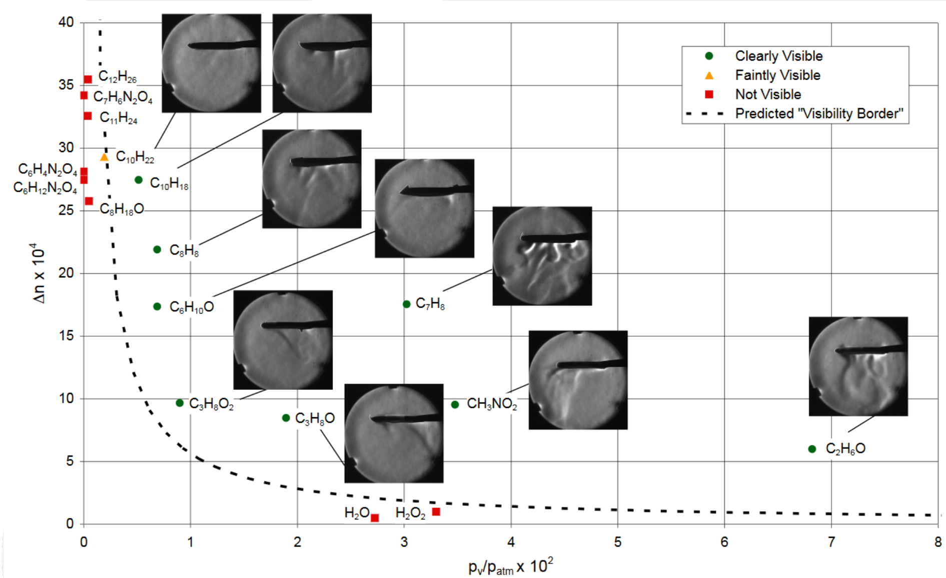
Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2008







Southwest Research Institute: Engineer → Research Engineer → Senior Research Engineer

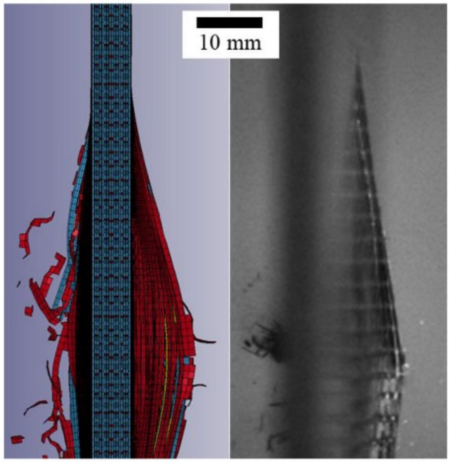
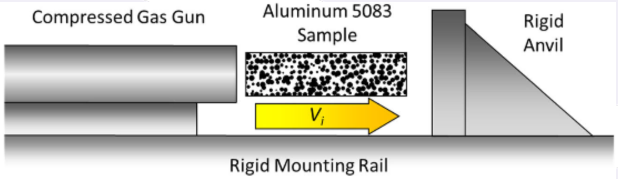


Fig. 30. Deflection from ballistic simulation of 6.35-mm-thick 2D CFRP at 240 m/s (left) is compared to high-speed video image from corresponding test (right) approximately 70 μs after impact.

Fig. 1 Basic Taylor impact experiment setup schematic



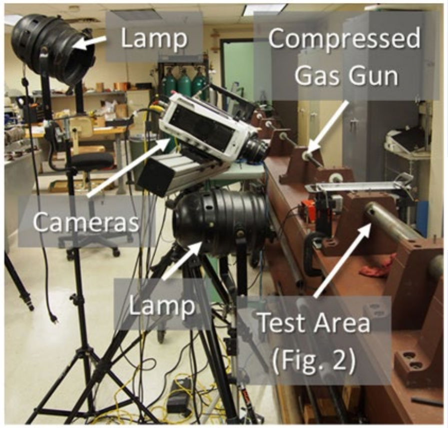


Fig. 3 Stereo DIC setup

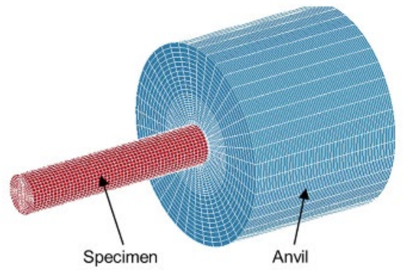


Fig. 12 The sample and anvil meshes used in the LS-DYNA simulations are shown

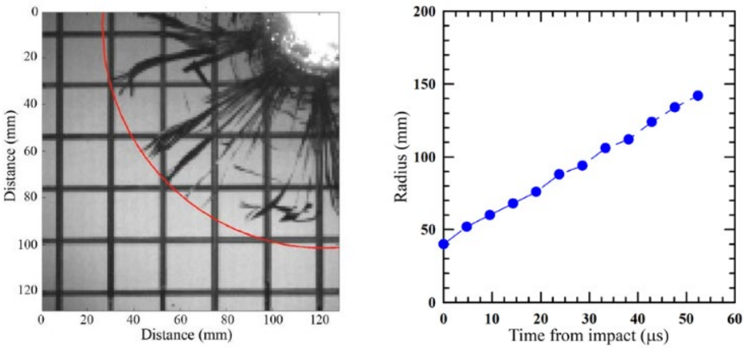


Figure 2. a) Measurement technique; **b)** Radius vs. time.

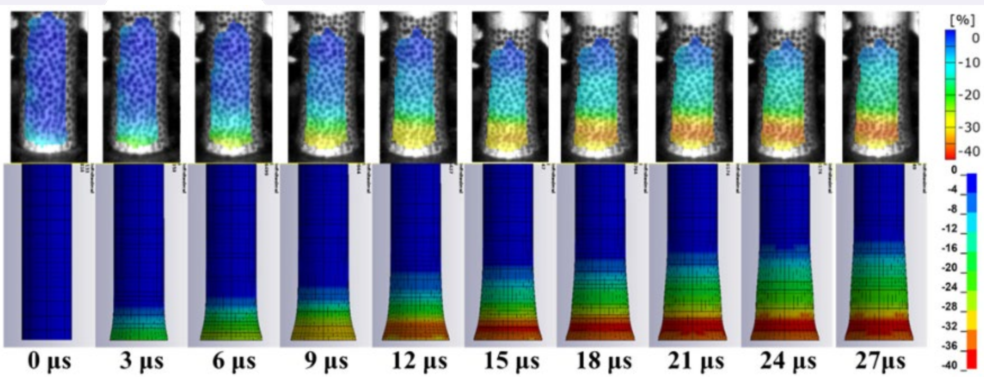


Fig. 14 Minimum principal strain evolution in time: DIC overlay on high-speed camera images (top) and from simulation (bottom) (Experiment TA-05)

Los Alamos National Laboratory: R&D Engineer

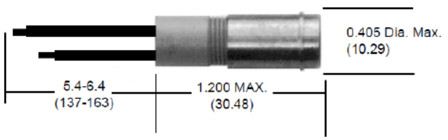
RP-1
EBW DETONATOR

RP-1 EBW Detonator

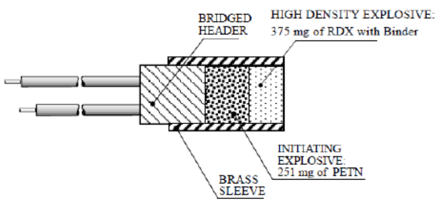
P/N 167-4314

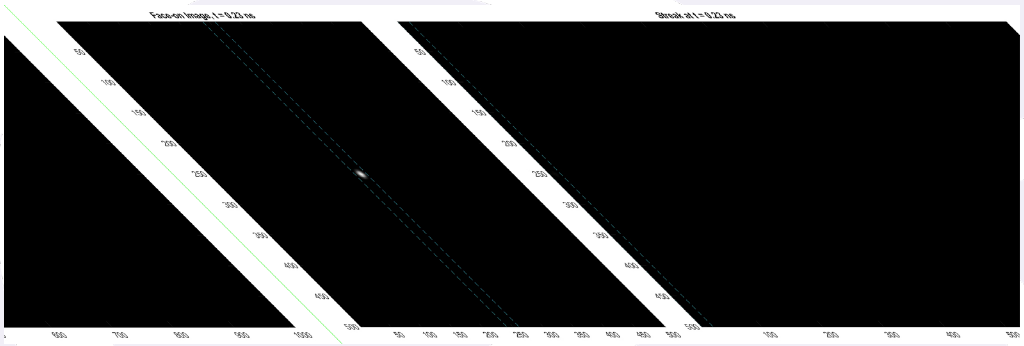
The RP-1 is a high precision Exploding Bridgewire Detonator manufactured by RISI which features close tolerance electrode spacing, precise bridgewire attachment, high quality loading sleeves and a rigidly controlled crystallization process of the PETN explosive and loading operation. Density is controlled through consistency of crystalline structure, precision weighing and class 'A' dies and tooling.

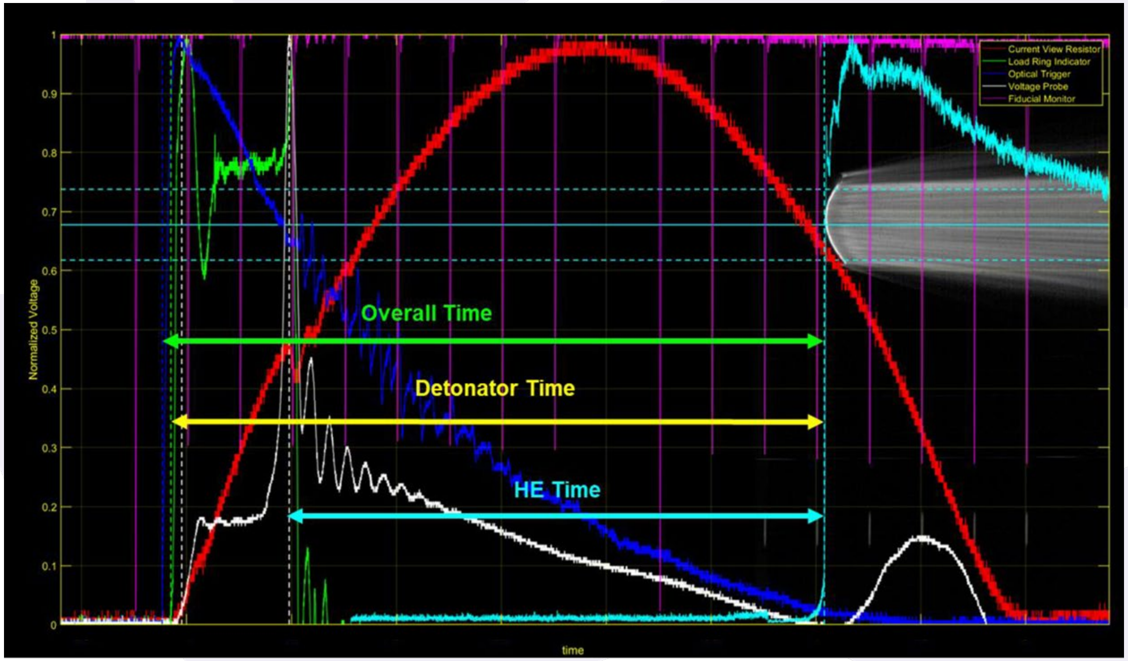
The result is a detonator with a transmission time simultaneity standard deviation of less than .025 microsecond. While some applications may not require this degree of timing or safety, users may want to take advantage of the high degree of reliability present in this detonator.



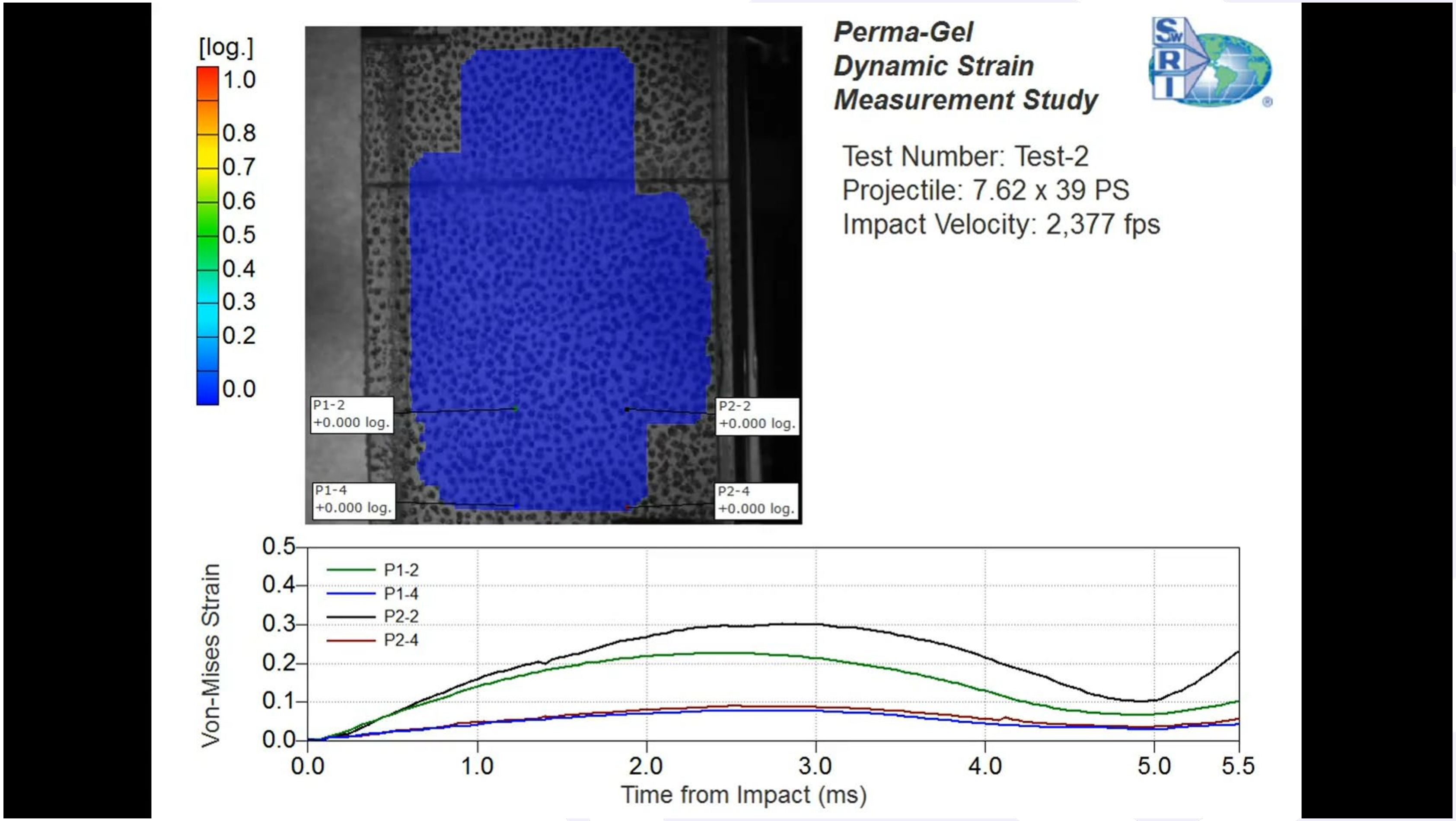
RP-1 EXPLOSIVE TRAIN



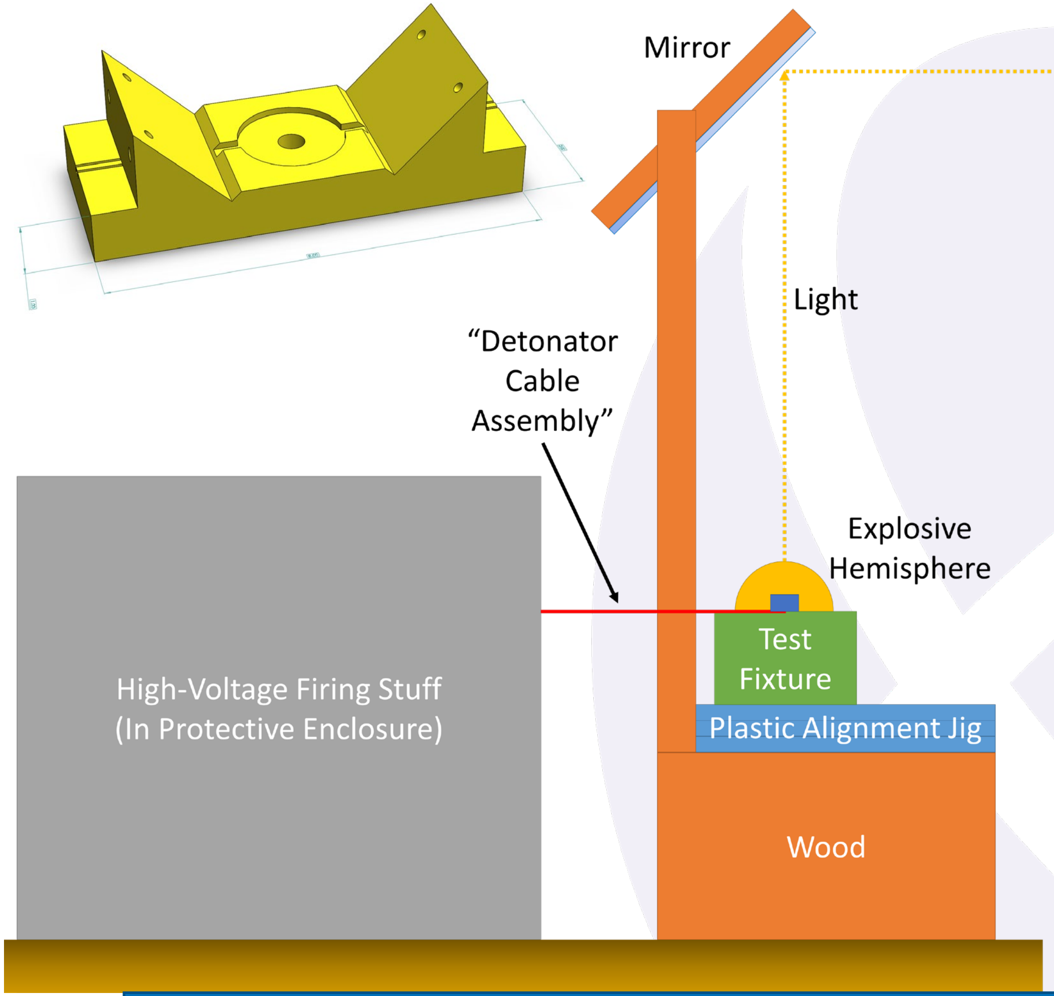


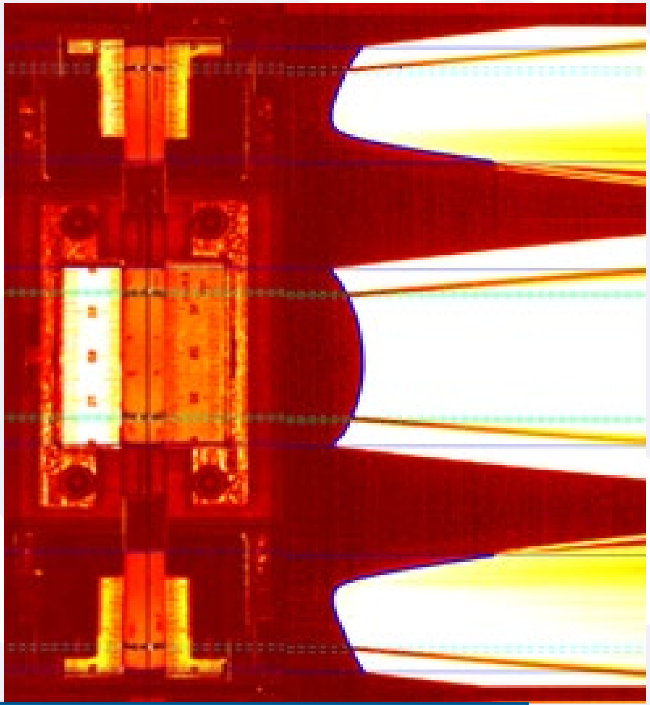


Video


[log.]
1.0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.0
P1-2
+0.000 log.
P2-2
+0.000 log.
P1-4
+0.000 log.
P2-4
+0.000 log.
Perma-Gel
Dynamic Strain
Measurement Study
Test Number: Test-2
Projectile: 7.62 x 39 PS
Impact Velocity: 2,377 fps
Von-Mises Strain
0.5
0.4
0.3
0.2
0.1
0.0
P1-2
P1-4
P2-2
P2-4
0.0
1.0
2.0
3.0
4.0
5.0
5.5
Time from Impact (ms)

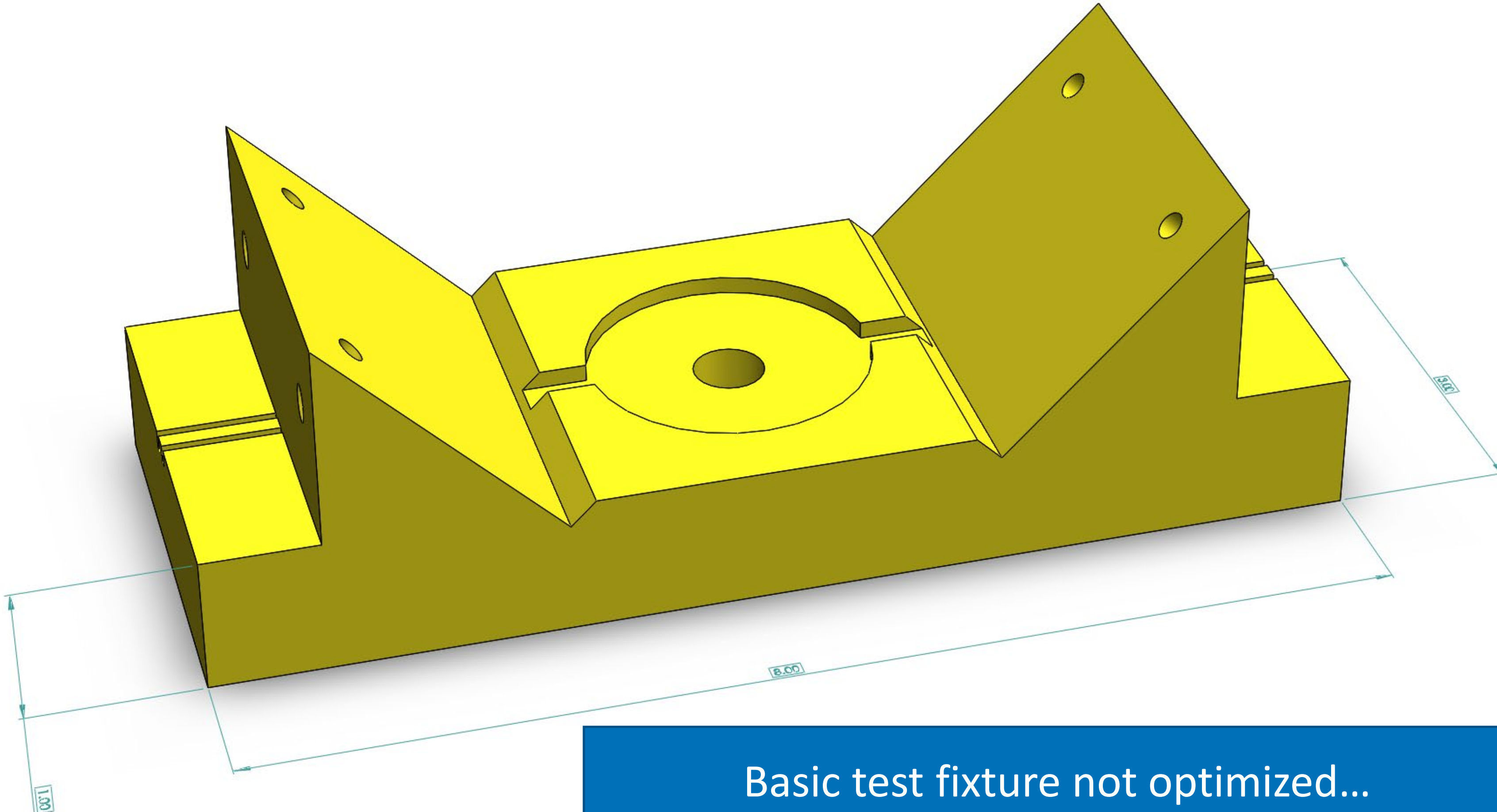
Project: The “V-Block” test fixture





For a given project we may repeat this test dozens of times….

Project: The “V-Block” test fixture



Basic test fixture not optimized…
Can we take advantage of additive manufacturing to make a better V-Block?

Project Goals

- Reduce weight of fixture
- Retain strength in key areas (need to be able to mount mirrors)
- Lower manufacturing costs
- Prints quickly without falling apart in printer

Use your knowledge and creativity to design the next-generation V-block to be used in future LANL qualification testing!